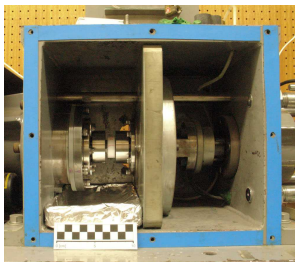
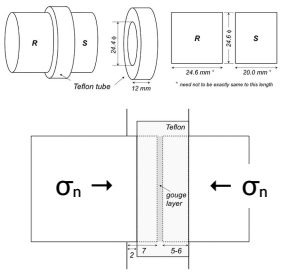
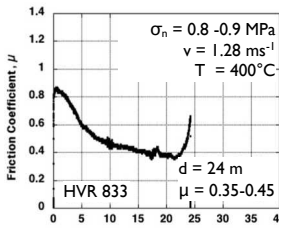
Grain size distribution and microstructures of experimentally sheared gouge - what do they tell us about seismic versus aseismic slip

Renée Heilbronner (1), Takehiro Hirose (2), Nynke Keulen (1), Holger Stünitz (3)

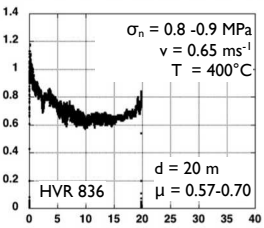
(1) Geological Institute, Basel University, 4056 Basel, Switzerland, *renee.heilbronner@unibas.ch
(2) Kochi Institute for Core Sample Research, JAMSTEC, Kochi, Japan
(3) University of Tromsø, Dept. of Geology, Tromsø, Norway



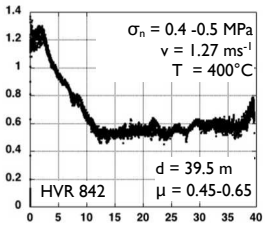




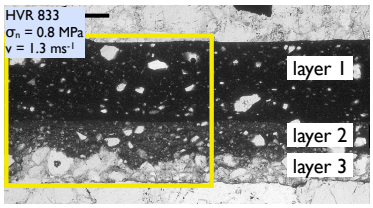
fast - high σ_n

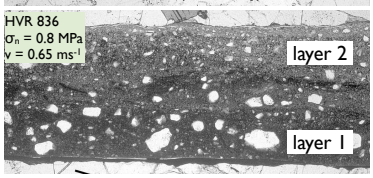


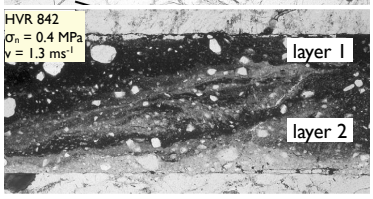
slow - high σ_n

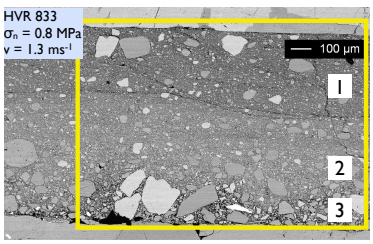


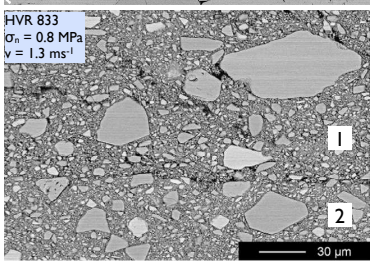
fast - low σ_n (long)

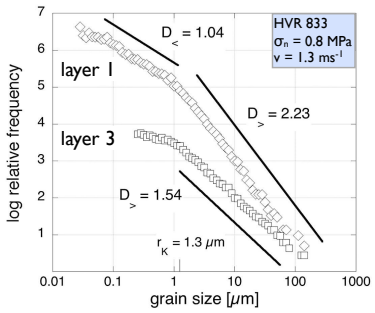


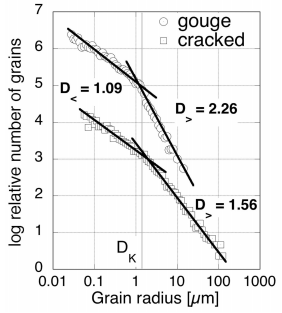






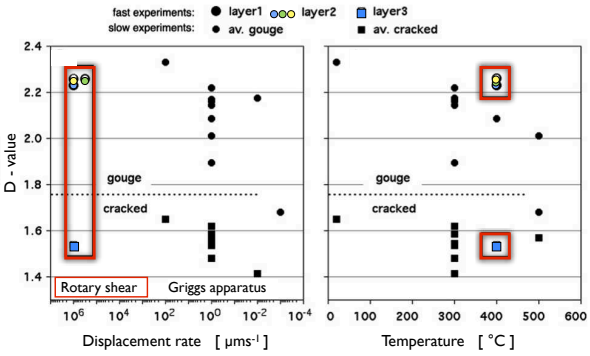






The granitoid gouge is velocity weakening, the weakening is less pronounced for a slower slip rate.

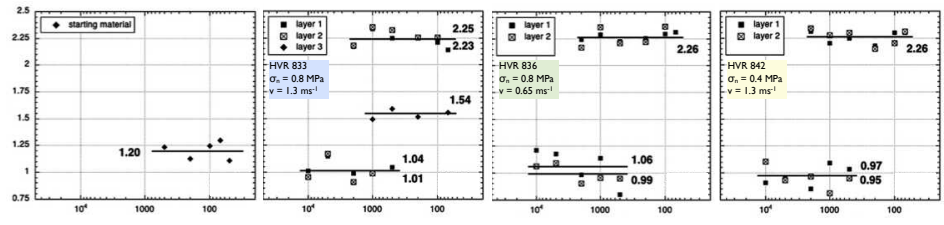
After small displacements ($\gamma \approx 20$), the GSD (log(n)/log(r)) reaches stable $D_>$ - values of 2.0 - 2.3 (for $r > r_K$). $D_>$ remains constant up to displacements of 40 m (γ up to 30'000). For very small grain sizes ($r < r_K$), $D_<$ is always ≈ 1.0.

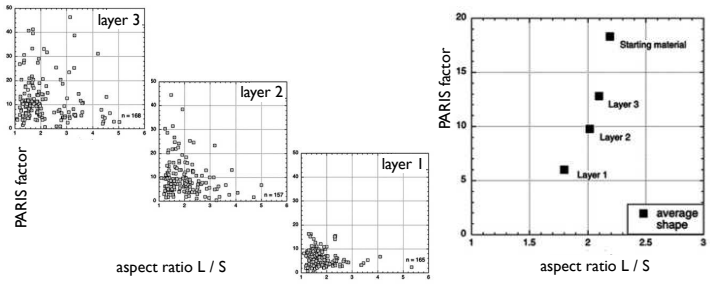


Stress dependence:
The GSD does not vary for normal stresses σ_n from 0.5 MPa to 500 MPa. Lower D-values only for $\sigma_n \approx 1$ GPa.

Slip rate dependence:
After reaching table values ($\gamma \approx 20$), D-values are the same for displacement rates, from ~1 μms-1 to 1.3 ms-1.
=> seismic and aseismic fault zones have same GSD

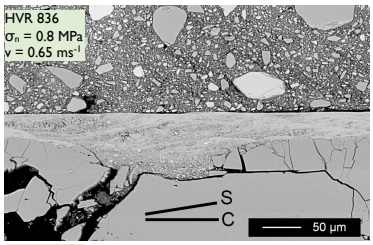
Temperature dependence:
In the range (300°C ≤ T ≤ 500°C), the GSD does not vary with temperature.

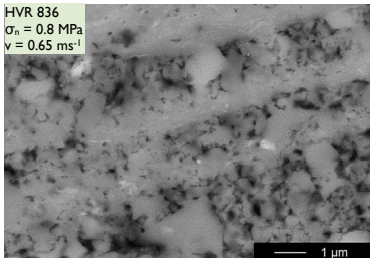




Shape development:
Grain shapes evolve during progressive slip towards more equant shapes (L/S from ~2.2 to ~1.8) with smoother and/or more convex grain boundaries (PARIS factor from ~20% to ~5%) .

Formation of fine-grained slip zones





Comminution is by spalling:
very small grain sizes are formed at clast boundaries;

for ($r < 1\,\mu m$): $D_< \approx 1.0$ and
for ($r < 1\,\mu m$): $D_> \approx 2.3$